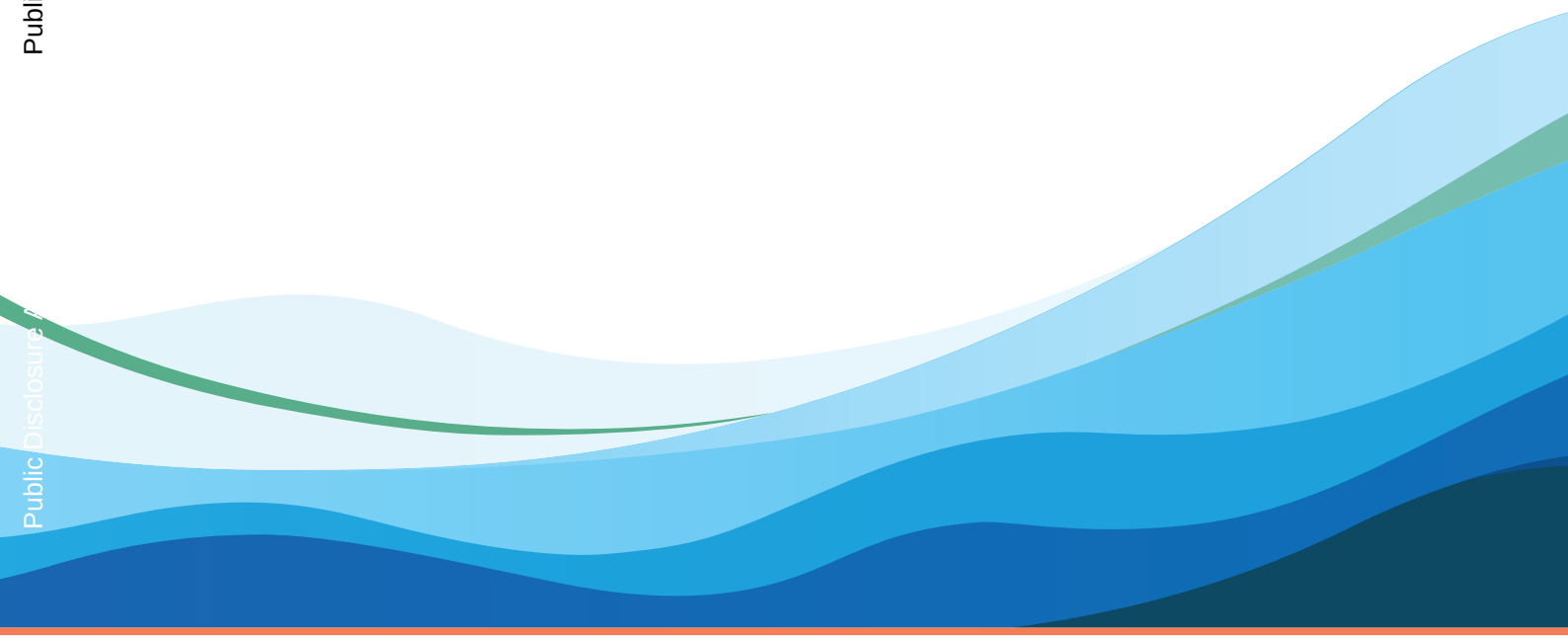
East Asia and Pacific Region: **MARINE PLASTICS SERIES**

Appendices

MARKET STUDY FOR THAILAND:

Plastics Circularity Opportunities and Barriers



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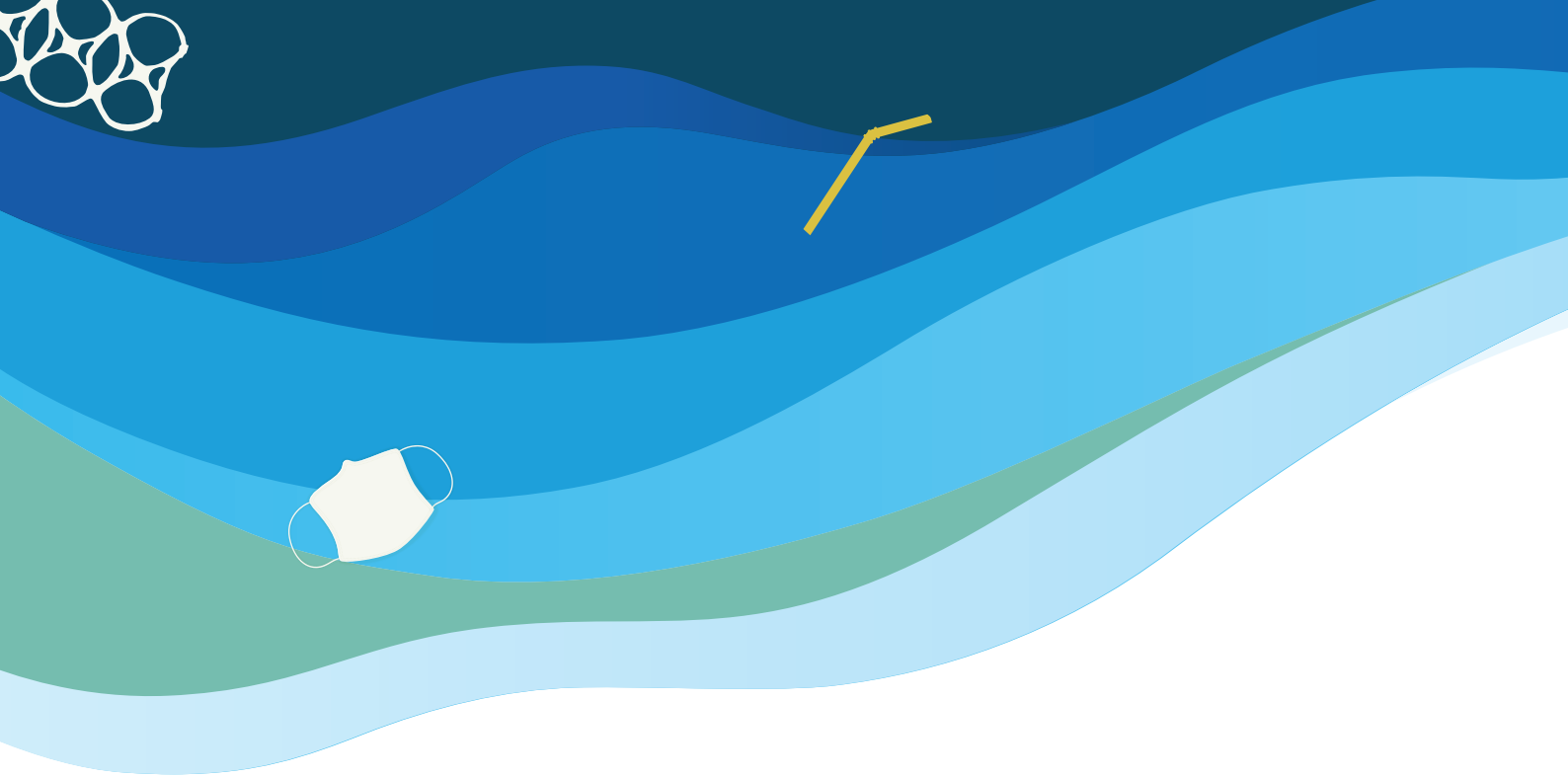

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Citation

World Bank Group 2021. *Market Study for Thailand: Plastics Circularity Opportunities and Barriers.* Marine Plastics Series, East Asia and Pacific Region. Washington DC.

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Appendices

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GA CIRCULAR

กรมควบคุมมลพิษ
POLLUTION CONTROL DEPARTMENT

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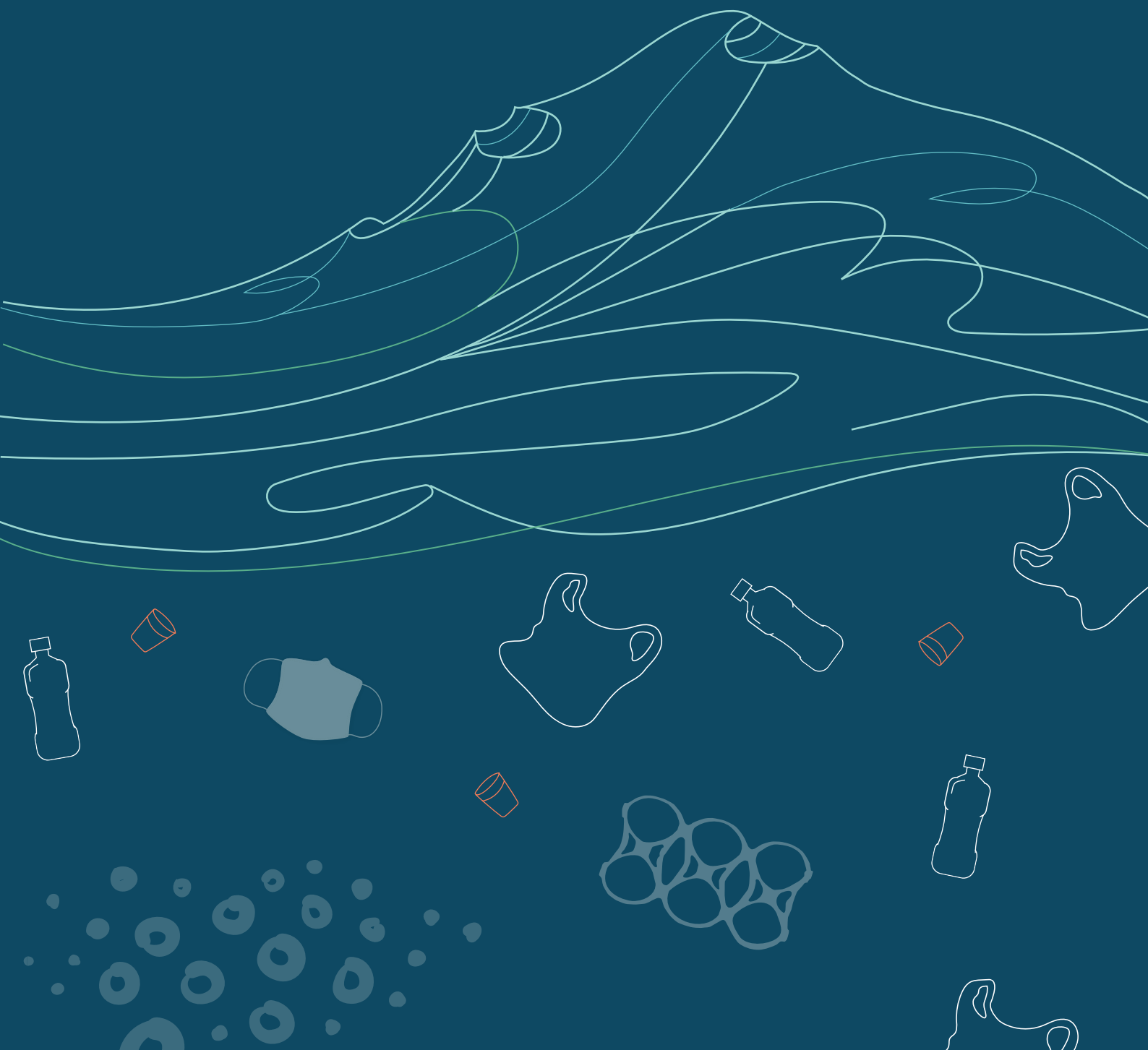


APPENDIX 1:

STAKEHOLDER ENGAGEMENT LIST

Table A1.1
ATTENDEE LIST OF STAKEHOLDER CONSULTATION WORKSHOPS

Name of stakeholder	Stakeholder category	Name of contact person	Position
Best Polymer International Co., Ltd	Company (Petrochemical)	Tawee Anantarattana	Managing Director
Best Polymer International Co., Ltd	Company (Petrochemical)	Suleeporn Phatthanapradit	Sales
Central Group	Company (Retail)	Butsalak Batmark	PR Manager
Central Retail Corporation Public Company Limited	Company (Retail)	ชัญญา ปวีณเมธา	Corporate Communication - Relations (AVP)
Coca-Cola Thailand	Company (Consumer Goods)	T. Nuntivat	Thailand Public Affairs, Communications and Sustainability Director
Coca-Cola Thailand	Company (Consumer Goods)	Wanpen Lolertpiphop	Thailand Public Affairs, Communications and Sustainability Manager
Customs Control Section	Govt (National)	Panu Limwongyuti	Director of Customs Control Section
Department of Local Administration	Govt (National)	Sirirut Bamrungsena	No position provided
Department of Marine and Coastal Resources	Govt (National)	Pakawan Talawat (Mod)	Coordinator
Department of Marine and Coastal Resources	Govt (National)	Suree Satapoomin	No position provided
Department of Marine and Coastal Resources	Govt (National)	Supawat Kan-atireklap	Marine and Coastal Ecosystem Resources and Environmental Research Specialist
Department of Marine and Coastal Resources	Govt (National)	Ms Ornuma JANYAPI-YAPHONG	Foreign Relations Officer, Strategy and Planning Division
Department of Marine and Coastal Resources	Govt (National)	นางพิมพ์วลัญช์ เชื้อผู้ดี	นักวิชาการประมงชำนาญการพิเศษ
Department of Industrial Works	Govt (National)	Patsaraporn	Director, Industrial Environmental Management Subdivision
Dow Chemicals	Company (Petrochemical)	Supot Katetopragran	Commercial Director
Dow Chemicals	Company (Petrochemical)	Ms. Poranee Kongamornpinyo	Thailand Corporate Affairs Director, Thailand PPP Plastics
EcoBlue Limited	Company(Processor/ Recycler)	Pranay Jain	Managing Director
EcoBlue Limited	Company (Processor/ Recycler)	Wichittara Samersai	Business Development Executive
GEPP	Company (Waste Collector)	Satatool	No position provided

Name of stakeholder	Stakeholder category	Name of contact person	Position
Global Compact Network Thailand	Multilateral/Development Agency	Thanyaporn Krichtitayawuth	Executive Director
Huhtamaki Thailand	Company(Convertor)	Sawitree Buranapaiboon	Innovation Director
Indorama Ventures	Company(Petrochemical)	Harsha Reddy	Head of Group Sustainability
Indorama Ventures	Company (Petrochemical)	Richard Jones	Head of Investor Relations & Corporate Communications
IUCN	Multilateral/Development Agency	Supranee Kampongsun	Head of Office
Novotel Bangkok Platinum	Company (Consumer Goods)	มนัสวี สงวนพันธ์	Talent & Culture Officer
NSTDA	University/Academia	Tipawan Tangjitpiboon	Senior analyst
Office of NESDC	Govt (National)	Ms. Vitsuta Boonmee	Plan and Policy Analyst
Office of NESDC	Govt (National)	Panittra Ntapanst	Plan and Policy Analyst
Office of NESDC	Govt (National)	บุญสิตา กิติคุณ	นักวิเคราะห์นโยบายและแผนปฏิบัติการ
Plastic Industry Club, The Federation of Thai Industries	Industry Association	Paradorn Chulajata	Honorable Chairman
Plastics Institute of Thailand	Industry Association	Kongsak D	No position provided
Plastics Institute of Thailand	Industry Association	Dome	No position provided
Plastics Institute of Thailand	Industry Association	Veera Kwanloetchit	President
Pollution Control Department	Govt (National)	Ms. Sunanta Phontavong	Environmentalist, Professional Level
Pollution Control Department	Govt (National)	Wassana Jangprajak	No position provided
Pollution Control Department	Govt (National)	Ms. Pornpimon Chareonsong	Director of Waste and Hazardous Substances Management Division
Pollution Control Department	Govt (National)	Vuttichat Kaewkrajang	Professional Level Environmentalist, Pollution Control Department
PTT Global Chemical PLC	Company(Petrochemical)	Savanit Boonyasuwat	Division Manager Sustainability Management
PTT Global Chemical PLC	Company (Petrochemical)	Khwanrudee Imardoon	Plan and Policy Analyst
PTT public company limited	Company (Petrochemical)	วิชุดา ทิพย์สุนารี	Analyst
Rayong Provincial Office for Local Administration	Govt (Provincial/Local)	นายพุฒิกร วิชัยดิษฐ์	อุตสาหกรรมจังหวัด
Rayong Provincial Office for Local Administration	Govt (Provincial/Local)	นายรัฐพงศ์ พูนเพชร	วิศวกรชำนาญการ
Rayong Provincial Office for Local Administration	Govt (Provincial/Local)	นายสิริชัย ฉลองนันทชัย	นักส่งเสริมการปกครองท้องถิ่นชำนาญการ
Rayong Provincial Office for Local Administration	Govt (Provincial/Local)	ธรวัฒน์ กองซัม	No position provided

Name of stakeholder	Stakeholder category	Name of contact person	Position
SCG Group (Chemicals)	Company (Petrochemical)	Vasimon Ruanglek	Innovative Alliances Manager, Circular Innovation & Partnerships
SCG Group (Chemicals)	Company (Petrochemical)	Chalermpol Hoonpongsimanont	Circular Economy Business Director
SCG Plastic Co., Ltd.	Company (Petrochemical)	Jaruwat Kittiyanan	Asistant Manager
SCG Plastic Co., Ltd.	Company (Petrochemical)	Roejarek Kanjanawarut	Chemical Business Biosciences, Environmental Solutions, & Circular Economy
Sermsuk Public Company Limited	Company(Consumer Goods)	Pitupong Soraphan	Vice President
Siam Makro Public Company	Company (Retail)	Wirat Wongpornpakdee	Representative
Stock Exchange of Thailand	Fund	Busaba Kongpanyakul	Deputy Head Research Department
Suez	Company (Processor/ Recycler)	Burin Tangsilpaolarn OR David Bourge	Project Development Manager OR General Manager
PTTGC	Company(Petrochemical)	Somchit Nilthanom	Sustainability Implementation Division
PTTGC	Company (Petrochemical)	Tamolwatt Gitwongwattana	System Engineer
Teijin Polyester (Thailand)	Company (Convertor)	Weerachai Christwathanyu	Manager, Non-Woven Material Sales Divison & Manager, Recycling Division
Thai Beverage Public Company Limited	Company (Consumer Goods)	Suthara Thienprapha	Advisor
Thai Beverage Recycle Company Limited	Company(Consumer Goods)	Orathai Poonsup	Managing Director
Thai Retailers Association	NGO/Foundation	Pattana Sudhirakuljai	Executive Director
Thailand Environment Institute (TEI)	NGO/Foundation	Orathai Pongruktham	No position provided
Thailand Environment Institute (TEI)	NGO/Foundation	Boonyaporn Juethong	Assistant Program Officer
Thailand Environment Institute (TEI)	NGO/Foundation	Pawin	Circular Economy Business Director
Thailand Environment Institute (TEI)	NGO/Foundation	Pinyada Charoensin	Assistant Program Officer
Thailand Environment Institute (TEI)	NGO/Foundation	Tanirat Tanawat	Project Manager
Thaiplastic Recycle Group co.,ltd	Company (Processor/ Recycler)	Atcharapond Tantilikitkul	ผู้จัดการ
The Swedish Embassy	Govt (International)	Louise Herrmann	First Secretary
Tourism Authority of Thailand	Govt(National)	Poonyapon Pradabsook	Chief of Learning Development Division
UNEP	Multilateral/Development Agency	Maggie Lee	Programme coordinator
UNEP	Multilateral/Development Agency	Martha Fernandez	Consultant

Name of stakeholder	Stakeholder category	Name of contact person	Position
Unilever Thailand	Company (Consumer Goods)	Nattinee Netraumpai	Head of External Affairs and Media Relations
Unilever Thailand	Company (Consumer Goods)	Vivekanand Sistla	R&D Director and Site Leader
Union J Plus	Compan y(Processor/ Recycler)	Chutikan Chaisiripaibool	Director
Union J Plus	Company (Processor/ Recycler)	กุลนาถ สิริผาติ	กรรมการ
UTCC	University/Academia	ชูธรรม ตั้งใจตรง	Professor
WATSONS	Company (Retail)	Saranporn Arwatchanajitt	Marketing Communica-tions Manager
Wongpanit Group	Company (Aggregator)	Wimonrat Santadvatana	International Coordi-nator
สถาบันสิงแวดล้อมไทย	NGO/Foundation	ภิญญดา เจริญสิน	ผู้จัดการโครงการ

Table A1.2
LIST OF PRIVATE SECTOR STAKEHOLDERS ENGAGED FOR IN-DEPTH INTERVIEWS

Name of stakeholder	Stakeholder category	Name of contact person	Position
BASF	Company (Convertor)	Lloyd Lowe	Head of Regional Sales
Billion Enterprise Co., Ltd.	Company (Processor/ Recycler)	Nuttakarn Mahasubsiri	Managing Director
Dow Chemicals	Company (Petrochemical)	Pratat Sutaputra	Associate Business & Supply Chain Planning Director
EcoBlue Limited	Company (Processor/ Recycler)	Pranay Jain	Managing Director
Envicco Ltd	Company (Petrochemical)	Natthanun Sirirak	Vice President, Business Development
GEPP Sa-Ard Co., Ltd.	Start-up	Mayuree Aroonwaranon	Co-founder & CEO
Indorama Ventures	Company (Petrochemical)	Aniwesh Tewari	Site Head, Recycling Business Unit
Interface Thailand	Company (Convertor)	Maxine Chen	Sustainability Communi-cations APAC
PTT Global Chemical PLC	Company (Petrochemical)	Savanit Boonyasuwat	Division Manager Sus-tainability Management
PTT MCC Biochem Co. Ltd.	Company (Petrochemical)	Wiboon Chuchepchunkamon	Acting Senior Vice President Green Chemicals Business Unit
SCG Group	Company (Petrochemical)	Chalermpol Hoonpongsi-manont	Circular Economy Business Director
SCG Group	Company (Petrochemical)	Vasimon Ruanglek	Innovative Alliances Manager, Circular Inno-vation & Partnerships
Siam City Cement / INSEE Cement (Ecocycle)	Company (Processor/ Recycler)	Dr. Vincent Aloysius	CEO, Ecocycle

Name of stakeholder	Stakeholder category	Name of contact person	Position
Suez	Company (Processor/ Recycler)	David Bourge	General Manager
Teijin Polyester (Thailand)	Company (Convertor)	Weerachai Christwathanyu	Manager, Non-Woven Material Sales; Manager, Recycling Business
Thai Bev	Company (Consumer Goods)	Vichate Tantiwanich	Senior Vice President, Corporate Affairs
Thai Beverage Recycle Co. Ltd (subsidiary of Thai Bev)	Company (Processor/ Recycler)	Orathai Poonsup	Managing Director
Unilever Thailand	Company (Consumer Goods)	Vivekanand Sistla	R&D Director and Site Leader
Wongpanit Group	Company (Aggregator)	Wimonrat Santadvatana	International Coordinator
ZingWhorThai Co., Ltd.	Company (Processor/ Recycler)	Wittaya Saw-Phrong	General Manager

Table A1.3
LIST OF POLICY EXPERTS ENGAGED FOR IN-DEPTH INTERVIEWS

Name of stakeholder	Stakeholder category	Name of contact person	Position
CITEO, France	Packaging Recovery Organization for France	Axel Darut	EU Policies & Data Advisor In The Circular Economy
Lidl Group	Company (Consumer Goods & Retailer)	Kristīne Doroško	Head of Sustainability for Baltics / Ex-Environmental Policy Manager, European Commission (Circular Economy Directorate)
Mae Fah Luang University	Academic	Dr. Panate Manomaivibool	Lecturer

APPENDIX 2:

METHODOLOGY DIFFERENCES BETWEEN MATERIAL FLOW ANALYSIS CONDUCTED BY PCD AND UNDER THIS WORLD BANK STUDY

Table A2.1
LIST OF POLICY EXPERTS ENGAGED FOR IN-DEPTH INTERVIEWS

Methodology Differences	Pollution Control Department MFA	MFA under Market Study by World Bank
Key Objective	To understand what happens to 8 specific single-use plastic products. To quantify the amount of the "mismatch" i.e. products that release into the environment.	To define the addressable market size in terms of tonnes and market value in plastics circularity in Thailand. To identify the barriers and opportunities for plastics recycling.
Materials Studied	MFA covers the post-consumption phase of plastics by studying plastics through 8 product types (e.g. bags, bottles, trays). Thus the total plastic covered in MFA is 1,936,594 tons (2017).	MFA covers plastics from production until post-consumption for all products under the 4 key resins (PET, PP, HDPE, LDPE/ LLDPE). Thus total plastic tons covered in MFA is 4,046,636 tons (2018).
Data Collection	The methodology uses employs on-ground surveys / audits of 9 locations in Thailand which allows for a breakdown into landfill & incineration vs leakage	The methodology uses in-depth stakeholder interviews with 20 public and private sector stakeholders from resin producers, convertors and recyclers and additional consultation with more stakeholders
Type of Product	Mainly consumer products as a focus	Covers all plastic products produce from the 4 key resins studied
Suggestion for further study outlined in report	Cover more products beyond the 8 target products. This recommendation was used in the World Bank MFA to cover all products.	For the identified priority actions to further identify the infrastructure capex and opex costs needed for implement the actions

APPENDIX 3:

RESIN USAGE BY INDUSTRY SECTOR

Table A3.1
RESIN USAGE BY INDUSTRY SECTOR

Industry Sector	Mean of Plastic Product Lifespan (Years)	Standard Deviation	Material Breakdown									
			LLDPE/LDPE		HDPE		PP		PET Bottle + Film		PET Polyester	
			Tonnes (2018)	Proportion (2018)	Tonnes (2018)	Proportion (2018)	Tonnes (2018)	Proportion (2018)	Tonnes (2018)	Proportion (2018)	Tonnes (2018)	Proportion (2018)
Packaging	0	0.83	708.17	83%	460.20	60%	681.00	50%	394.33	95%	0.00	0%
Construc-tion	20	0.83	8.56	1%	138.06	18%	54.48	4%	0.00	0%	258.27	30%
E&E	10	0.83	51.36	6%	30.68	4%	136.20	10%	8.30	2%	0.00	0%
Automo-tive	15	0.83	0.00	0%	7.67	1%	204.30	15%	0.00	0%	0.00	0%
Textile	5	0.83	0.00	0%	0.00	0%	0.00	0%	0.00	0%	602.64	70%
Recre-ation	10	0.83	0.00	0%	7.67	1%	68.10	5%	0.00	0%	0.00	0%
Footwear	2	0.83	38.17	4%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Filament non-tex-tile	0	0.83	0.00	0%	61.36	8%	40.86	3%	0.00	0%	0.00	0%
Medical	0	0.83	3.47	0%	0.00	0%	13.62	1%	4.15	1%	0.00	0%
Lens	0	0.83	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Agricul-ture	5	0.83	30.77	4%	38.35	5%	13.62	1%	0.00	0%	0.00	0%
Houseware	5	0.83	6.94	1%	15.34	2%	136.20	10%	4.15	1%	0.00	0%
Safety	5	0.83	0.00	0%	0.00	0%	13.62	1%	4.15	1%	0.00	0%
Security	5	0.83	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
Security	5	0.83	8.56	1%	7.67	1%	0.00	0%	0.00	0%	0.00	0%
Total			856.00	100%	767.00	100%	1,362.00	100%	415.09	100%	860.91	100%

Source: Plastics Institute of Thailand

APPENDIX 4:

DATA SOURCES AND KEY ASSUMPTIONS FOR MATERIAL VALUE LOSS CALCULATIONS

Table A4.1
PET PACKAGING

Data Points	Value	Units
PET Bottle/Sheet Consumption	382,255	TPY
Recycling rate (PET Packaging)	27%	%
CFR (PET Packaging)	31%	%
Process losses (PET Packaging)	12%	%
Recycling rate (PET Packaging)	54%	%
CFR (PET Packaging)	62%	%
Average Global Q4 price - Food grade rPET	1,369	USD / ton
Average Global Q4 price - rPOY	1,250	USD / ton
Average Global Q4 price - Flakes	953	USD / ton
MVRP allocation - food-grade rPET pellets	50%	%
MVRP allocation - rPOY	30%	%
MVRP allocation - rPET flakes /PSF	20%	%
Weighted average MVRP price used for PET calculations	1,250	USD / ton

Post-Consumer Destination		Tonnage	Price (USD/Tonne)	Price Difference from MVRP	Total Value Lost (Millions USD)	Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Food-grade	11,429	$1,369	-$119	-$1	$360
	Non-food grade	92,459	$1,101	$149	$14	
	Not recycled	278,367	$0	$1,250	$348	
High Range Estimate of Recycling Rate	Food-grade	11,429	$1,369	-$119	-$1	$246
	Non-food grade	196,347	$1,101	$149	$29	
	Not recycled	174,479	$0	$1,250	$218	

Post-Consumer Destination		Post-Consumer Destination (as a % of market inputs)	Weighted average price difference from MVRP	Price yield (a)	Volume yield (b)	Value yield (a x b) [Y-AXIS]	Collected for recycling rate [X-AXIS]	Material value unlocked [X-AXIS x Y-AXIS]
Low Range Estimate of Recycling Rate	Food-grade	11.00%	$119	90.46%	88.00%	79.60%	30.88%	24.58%
	Non-food grade	89.00%						
	Not recycled							
High Range Estimate of Recycling Rate	Food-grade	5.50%	$134	89.28%	88.00%	78.57%	61.77%	48.53%
	Non-food grade	94.50%						
	Not recycled							

Post-Consumer Destination		Theoretical max of material value unlocked (MVRP Price x Total tonnage of resin) (Millions USD)	Value unlocked (after factoring in process loss) Total Lost (Millions USD)	Value lost Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Food-grade	$523	$129	$395
	Non-food grade			
	Not recycled			
High Range Estimate of Recycling Rate	Food-grade		$254	$269
	Non-food grade			
	Not recycled			

Table A4.2
PET POLYESTER

Data Points	Value	Units
PET Polyester Consumption	437,106	TPY
Average Global Q4 price - rPOY	1,250	USD / ton
Average Global Q4 price - Flakes	953	USD / ton
Polyester CFR (Low Range)	0%	%
Polyester CFR (High Range)	5%	%
MVRP allocation - rPOY	30%	%
MVRP allocation - rPET flakes /PSF	70%	%
Weighted average MVRP price used for PET calculations	1,042	USD / ton

Post-Consumer Destination		Tonnage	Price (USD/Tonne)	Price Difference from MVRP	Total Value Lost (Millions USD)	Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Recycled	0	$953	$89	$0	$455
	Not recycled	437,106	$0	$1,042	$455	
High Range Estimate of Recycling Rate	Recycled	21,855	$953	$89	$2	$435
	Not recycled	415,250	$0	$1,042	$433	

Post-Consumer Destination		Post-Consumer Destination (as a % of market inputs)	Weighted average price difference from MVRP	Price yield (a)	Volume yield (b)	Value yield (a x b) [Y-AXIS]	Collected for recycling rate [X-AXIS]	Material value unlocked [X-AXIS x Y-AXIS]
Low Range Estimate of Recycling Rate	Recycled	100.00%	$89	91.44%	88.00%	80.47%	0.00%	0.00%
	Not recycled							
High Range Estimate of Recycling Rate	Recycled	100.00%	$89	91.44%	88.00%	80.47%	5.00%	4.02%
	Not recycled							

Post-Consumer Destination		Theoretical max of material value unlocked (MVRP Price x Total tonnage of resin) Total Lost (Millions USD)	Value unlocked (after factoring in process loss) Total Lost (Millions USD)	Value lost Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Recycled	$598	$0	$598
	Not recycled			
High Range Estimate of Recycling Rate	Recycled		$24	$574
	Not recycled			

Table A4.3
PP

Data Points	Value	Units
PP Consumption	1,177,821	TPY
Process losses	12%	%
CFR (Low Range)	10%	%
Recycling rate (Low Range)	9%	%
CFR (High Range)	20%	%
Recycling rate (High Range)	18%	%
Average Global Q4 price - rPP Homo black, rPP Copo black	881	USD / ton
rPP black pellets price	827	USD / ton
rPP natural pellets price	1,110	USD / ton
rPP food grade natural pellets price	1,388	USD / ton
Proportion of rPP black pellets produced in TH	80%	%
Proportion of rPP natural produced in TH	20%	%
MVRP allocation - food-grade rPP pellets	40%	%
MVRP allocation - natural rPP pellets	40%	%
MVRP allocation - black rPP pellets	20%	%
Weighted average MVRP price used for PP calculations	1,164	USD / ton

Post-Consumer Destination		Tonnage	Price (USD/Tonne)	Price Difference from MVRP	Total Value Lost (Millions USD)	Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Black	92,577	$827	$337	$31	$1,269
	Natural	23,144	$1,110	$54	$1	
	Not recycled	1,062,099	$0	$1,164	$1,237	
High Range Estimate of Recycling Rate	Black	188,451	$827	$337	$64	$1,163
	Natural	47,113	$1,110	$54	$3	
	Not recycled	942,257	$0	$1,164	$1,097	

Post-Consumer Destination		Post-Consumer Destination (as a % of market inputs)	Weighted average price difference from MVRP	Price yield (a)	Volume yield (b)	Value yield (a x b) [Y-AXIS]	Collected for recycling rate [X-AXIS]	Material value unlocked [X-AXIS x Y-AXIS]
Low Range Estimate of Recycling Rate	Black	80.00%	$281	75.88%	88.00%	66.78%	9.83%	6.56%
	Natural	20.00%						
	Not recycled							
High Range Estimate of Recycling Rate	Black	80.00%	$281	75.88%	88.00%	66.78%	20.00%	13.36%
	Natural	20.00%						
	Not recycled							

Post-Consumer Destination		Theoretical max of material value unlocked (MVRP Price x Total tonnage of resin) (Millions USD)	Value unlocked (after factoring in process loss) Total Lost (Millions USD)	Value lost Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Black	$1,371	$90	$1,281
	Natural			
	Not recycled			
High Range Estimate of Recycling Rate	Black		$183	$1,188
	Natural			
	Not recycled			

Table A4.4
HDPE

Data Points	Value	Units
PP Consumption	658,473	TPY
Process losses	12%	%
CFR (Low Range)	8%	%
Recycling rate (Low Range)	7%	%
CFR (High Range)	25%	%
Recycling rate (High Range)	22%	%
rHDPE Food Grade pellets (MVRP)	1,638	USD / ton
rHDPE Natural pellets	1,132	USD / ton
rHDPE pipe grade black pellets	821	USD / ton
rHDPE GP Black pellets	755	USD / ton
rHDPE mixed colored	733	USD / ton
Proportion of rHDPE Natural pellets produced in TH	30%	%
Proportion of rHDPE pipe grade black produced in TH	20%	%
Proportion of rHDPE GP black produced in TH	20%	%
Proportion of rHDPE mixed colored produced in TH	30%	%

Continued on the next page.

Data Points	Value	Units
MVRP allocation - Food Grade pellets	30%	%
MVRP allocation - natural rHDPE pellets	45%	%
MVRP allocation - pipe grade black rHDPE pellets	25%	%
Weighted average MVRP price used for HDPE calculations	1,206	USD / ton

Post-Consumer Destination		Tonnage	Price (USD/Tonne)	Price Difference from MVRP	Total Value Lost (Millions USD)	Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Natural	14,625	$1,132	$74	$1	$752
	GP Black	9,750	$821	$385	$4	
	Pipe Grade Black	9,750	$755	$451	$4	
	Mixed Colored	14,625	$733	$473	$7	
	Not Recycled	609,725	$0	$1,206	$735	
High Range Estimate of Recycling Rate	Natural	43,459	$1,132	$74	$3	$667
	GP Black	28,973	$821	$385	$11	
	Pipe Grade Black	28,973	$755	$451	$13	
	Mixed Colored	43,459	$733	$473	$21	
	Not Recycled	513,609	$0	$1,206	$619	

Post-Consumer Destination		Post-Consumer Destination (as a % of market inputs)	Weighted average price difference from MVRP	Price yield (a)	Volume yield (b)	Value yield (a x b) [Y-AXIS]	Collected for recycling rate [X-AXIS]	Material value unlocked [X-AXIS x Y-AXIS]
Low Range Estimate of Recycling Rate	Natural	30.00%	$331	72.52%	88.00%	63.82%	8.41%	5.37%
	GP Black	20.00%						
	Pipe Grade Black	20.00%						
	Mixed Colored	30.00%						
	Not Recycled							
High Range Estimate of Recycling Rate	Natural	30.00%	$331	72.52%	88.00%	63.82%	25.00%	15.95%
	GP Black	20.00%						
	Pipe Grade Black	20.00%						
	Mixed Colored	30.00%						
	Not Recycled							

Post-Consumer Destination		Theoretical max of material value unlocked (MVRP Price x Total tonnage of resin) (Millions USD)	Value unlocked (after factoring in process loss) Total Lost (Millions USD)	Value lost Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Natural	$1,078	$58	$1,020
	GP Black			
	Pipe Grade Black			
	Mixed Colored			
	Not Recycled			
High Range Estimate of Recycling Rate	Natural		$172	$906
	GP Black			
	Pipe Grade Black			
	Mixed Colored			
	Not Recycled			

Table A4.5
LDPE/LLDPE

Data Points	Value	Units
PP Consumption	835,301	TPY
Process losses	12%	%
CFR (Low Range)	9%	%
Recycling rate (Low Range)	8%	%
CFR (High Range)	25%	%
Recycling rate (High Range)	22%	%
rLDPE Natural pellets	929	USD / ton
rLDPE black pellets	741	USD / ton
rLDPE mixed colored pellets	650	USD / ton
Proportion of rLDPE Natural pellets produced in TH	20%	%
Proportion of rLDPE Black produced in TH	40%	%
Proportion of rLDPE Mixed Colored produced in TH	40%	%
MVRP allocation - Natural rLDPE pellets	40%	%
MVRP allocation - rLDPE black pellets	40%	%
MVRP allocation - mixed colored rLDPE pellets	20%	%
Weighted average MVRP price used for LDPE calculations	798	USD / ton

Post-Consumer Destination		Tonnage	Price (USD/Tonne)	Price Difference from MVRP	Total Value Lost (Millions USD)	Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Natural	13,230	$929	-$131	-$2	$617
	Black	26,460	$741	$57	$2	
	Mixed Colored	26,460	$650	$148	$4	
	Not recycled	769,151	$0	$798	$614	
High Range Estimate of Recycling Rate	Natural	36,753	$929	-$131	-$5	$530
	Black	73,507	$741	$57	$4	
	Mixed Colored	73,507	$650	$148	$11	
	Not recycled	651,535	$0	$798	$520	

Post-Consumer Destination		Post-Consumer Destination (as a % of market inputs)	Weighted average price difference from MVRP	Price yield (a)	Volume yield (b)	Value yield (a x b) [Y-AXIS]	Collected for recycling rate [X-AXIS]	Material value unlocked [X-AXIS x Y-AXIS]
Low Range Estimate of Recycling Rate	Natural	20.00%	$56	93.99%	88.00%	82.71%	9.00%	7.44%
	Black	40.00%						
	Mixed Colored	40.00%						
	Not recycled							
High Range Estimate of Recycling Rate	Natural	20.00%	$56	93.99%	88.00%	82.71%	25.00%	20.68%
	Black	40.00%						
	Mixed Colored	40.00%						
	Not recycled							

Post-Consumer Destination		Theoretical max of material value unlocked (MVRP Price x Total tonnage of resin) (Millions USD)	Value unlocked (after factoring in process loss) Total Lost (Millions USD)	Value lost Total Lost (Millions USD)
Low Range Estimate of Recycling Rate	Natural	$776	$58	$718
	Black			
	Mixed Colored			
	Not recycled			
High Range Estimate of Recycling Rate	Natural		$160	$616
	Black			
	Mixed Colored			
	Not recycled			

Table A4.6

SUMMARY OF MATERIAL VALUE LOST FOR EACH RESIN

Resin	Low Range (USD Millions)	High Range (USD Millions)
PP	$1,188	$1,281
HDPE	$906	$1,020
LDPE/LLDPE	$616	$718
PET Polyester	$574	$598
PET Packaging	$269	$395
Total	$3,554	$4,013

APPENDIX 5:

ASSUMPTIONS AND CONDITIONS BEHIND CALCULATION OF THE IMPACT OF INTERVENTION

Table A5.1
ASSUMPTIONS AND CONDITIONS BEHIND CALCULATION OF THE IMPACT OF INTERVENTION

#	Recommendations	Modeling Assumptions	CFR Rate Increase	Value Yield Increase
1	**INTERVENTIONS THAT INCREASE VALUE YIELD AND CFR RATE**			
A	Increase sorting efficiency	CFR rate: Implementing this intervention will increase MSW sorting to 50% of all collected MSW, so currently non-recycled plastics reduces by 50%. Assumes there will be a 100% collection of MSW. This leads to an increase in CFR rate of 41%. Value Yield: Implementing this intervention will increase demand for all products by approximately 10% of existing value due to better sorting. Note: Currently only 7% of non-recycled plastics (and 7% of all plastics consumed in Thailand) now goes into WTE as per cell B57 in "Waste Collection Costs" tab). So value from WTE is currently very minimal or non-existent	41%	7%
B	Set recycled content targets across all major end-use applications	CFR rate: Assuming 30% recycled content all comes from local sources and 10% process losses occur, a minimum CFR rate of 33% is required inorder to achieve a 30% recycled content target. Also, it is assumed that currently 50% of all recycled plastics is exported. When recycled content targets are set, it is assumed only 25% of all recycled plastics will be exported i.e. local demand for recycled plastics will increase to 75% of all recycled plastics. So we need 44% CFR rate such that 75% of that becomes 33% CFR rate. Thus the increase in CFR rate needed is 44%-17.6%=26.4% i.e. 26% Value Yield: Implementing this intervention will increase demand for all products by approximately 15% of existing value	26%	11%
C	Mandate "design for recycling" standards for all plastics, especially for packaging	CFR rate: Based on Ellen MacArthur Foundation's New Plastics Economy Catalysing Action report, without fundamental redesign and innovation about 30% of plastic packaging will never be reused or recycled. Assuming this 30% can be applied across all applications of plastics moves CFR to right by 30% Value Yield: Based on the above mentioned report, implementing four areas of packaging design changes could have a positive impact on recycling economics amounting to USD 90-140 per tonne collected	30%	13%

#	Recommendations	Modeling Assumptions	CFR Rate Increase	Value Yield Increase
2	**INTERVENTIONS THAT INCREASE CFR RATE**			
D	Encourage increase in recycling capacities (mechanical and chemical)	CFR rate: 100% recycling capacity is needed to achieve very high recycling rates for plastics. Assuming the current value yield stays the same as recycling capacity increases to 100% Value Yield: No change	82%	9%
E	Create industry-specific requirements to collect post-use products	CFR Rate: Assuming a 90% CFR rate target for packaging and 50% CFR rate target for all non-packaging applications. 42% of all plastics is consumed by packaging and the rest by non-packaging so this provides a weighted average CFR rate of 67% to be reached. After factoring in the existing CFR rate of 17.6%, the increase in CFR rate is 49% Value Yield: No change	49%	0%
F	Restrict disposal of plastics and illegal dumping	CFR Rate: Implementing this intervention will reduce all non-recycled plastics from entering landfills by 50%. This leads to an increase in CFR rate of 42%. Value Yield: No change	41%	0%

APPENDIX 6:

SUMMARY OF ALL RECOMMENDED INTERVENTIONS AND ACTIONS

Table A6.1
SUMMARY OF ALL RECOMMENDED INTERVENTIONS AND ACTIONS

Recommended Interventions	#	Actions
A. Increase sorting efficiency	1	Mandate and harmonize source-segregation and separate collection standards
	2	Establish dedicated Material Recovery Facilities (MRFs) or sorting centers
	3	Develop awareness & behavior change campaigns
	4	Provide opportunities for informal sector inclusion
	5	Digitalize recyclables collection
	6	Implement Pay-as-you-throw waste collection model
B. Set recycled content targets across all major end-use applications	7	Allow the use of recycled plastics in food-contact applications
	8	Set recycled content targets & standards for major plastic use industries
	9	Develop & launch incentives for using recycled content usage
	10	Implement green public procurement of recycled plastic products
	11	Tax plastic applications without minimum recycled content
C. Mandate "design for recycling" standards for plastics, especially for packaging	12	Align industries on "design for recycling" standards
	13	Voluntarily adopt "design for recycling" standards for all plastic products
	14	Mandate national "design for recycling" standards for packaging plastics
D. Encourage increase in recycling capacities (mechanical and chemical)	15	Incentivize increase in recycling capacities for polyolefins
	16	Incentivize PET recycling to higher-end recycled products
	17	Provide market pricing & volume data for virgin & recycled plastics
	18	Invest in chemical recycling capacity for low value plastics
E. Create industry-specific requirements to collect post-use products	19	Setup voluntary extended producer responsibility system (e.g. PRO)
	20	Mandate collection targets for packaging & electronics industries
	21	Mandate reporting framework for plastic products
	22	Mandate trading of plastic collection credits to meet targets
F. Restrict disposal of plastics & illegal dumping	23	Update HS codes for import / export of plastic resins & products
	24	Assess feasibility of regional scrap plastics trade
	25	Mandate targets to lower landfill disposal rates for plastics
	26	Increase landfill tipping fees
	27	Ensure separate collection of biodegradable plastics

APPENDIX 7:

COMPARISON OF VIRGIN AND RECYCLED RESINS AND OIL PRICES

Figure A7.1
PET

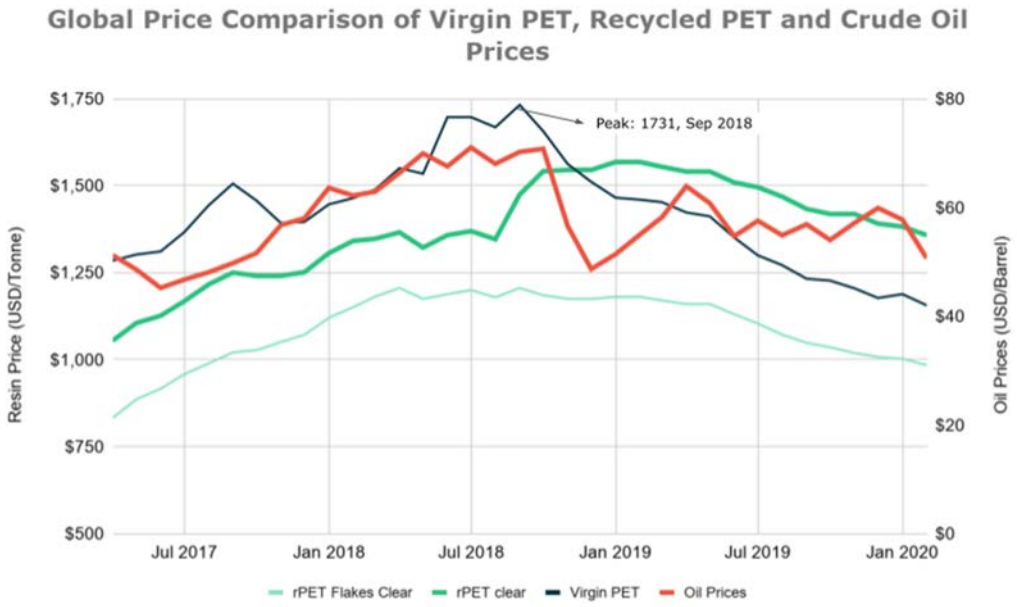


Figure A7.2
PP

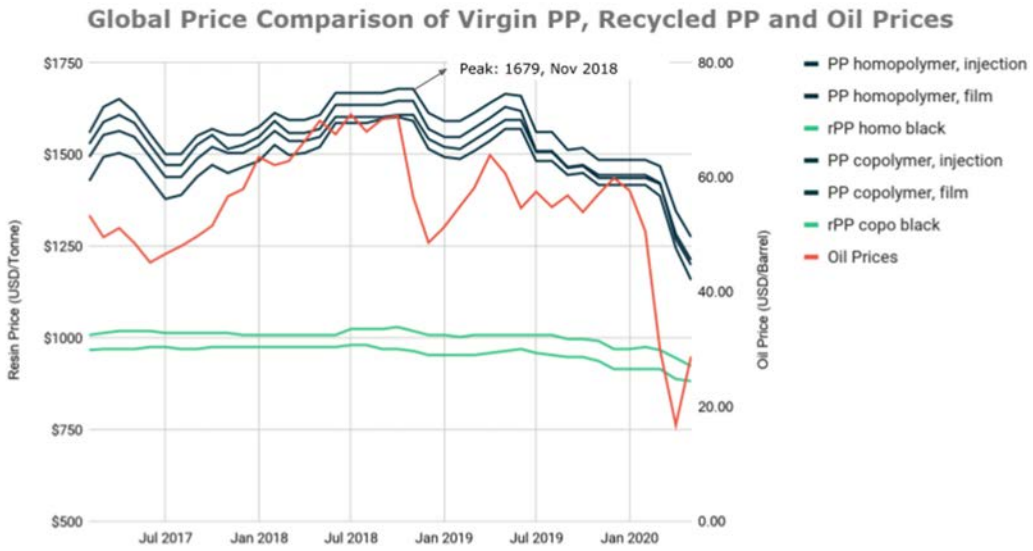


Figure A7.3
HDPE

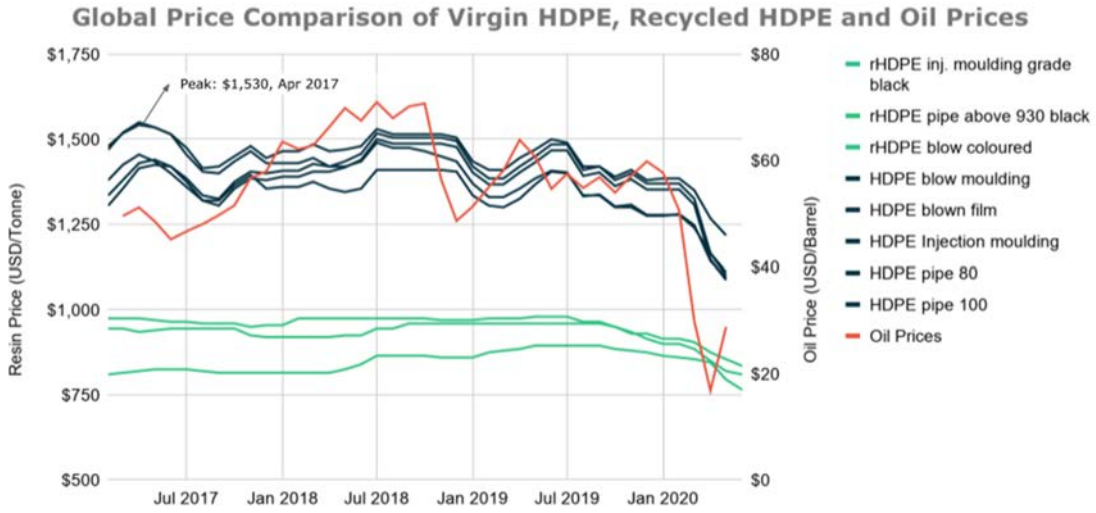
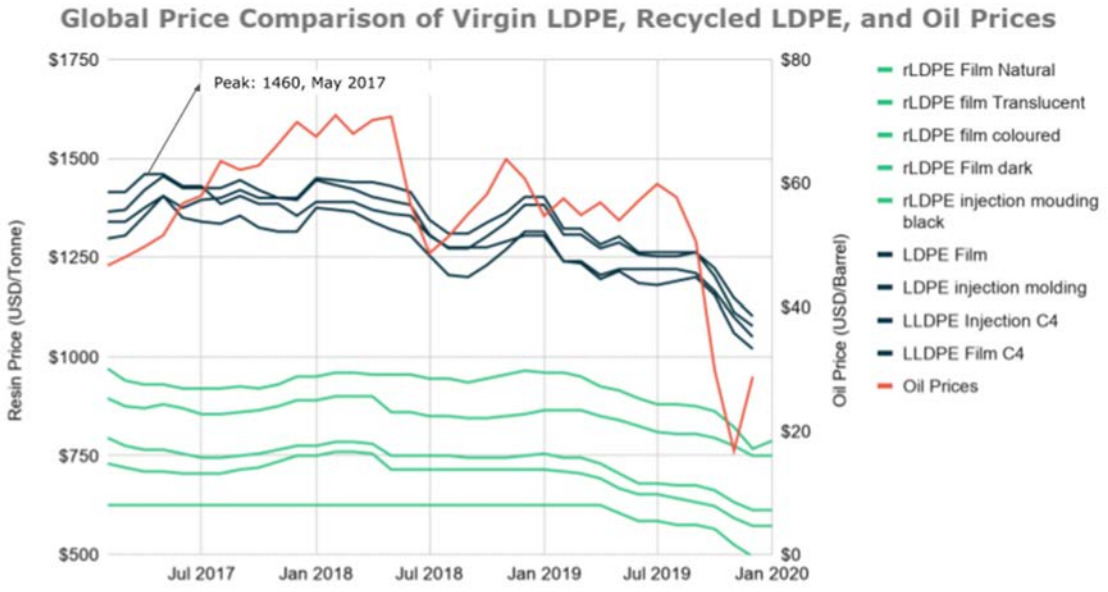


Figure A7.4
LDPE



APPENDIX 8:

MARKET SHARE OF STAKEHOLDERS ENGAGED

Figure A8.1
MARKET SHARE OF RESIN PRODUCERS ENGAGED

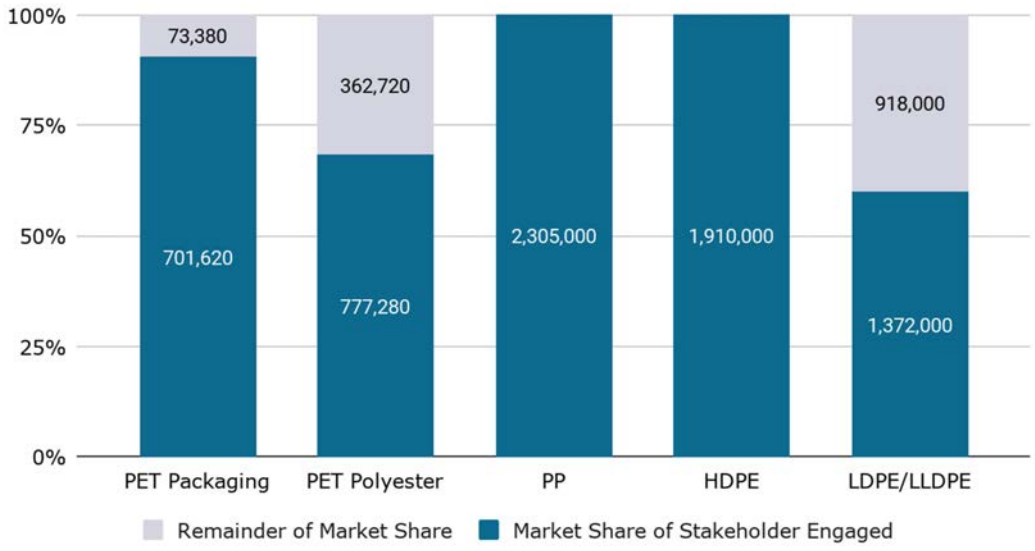
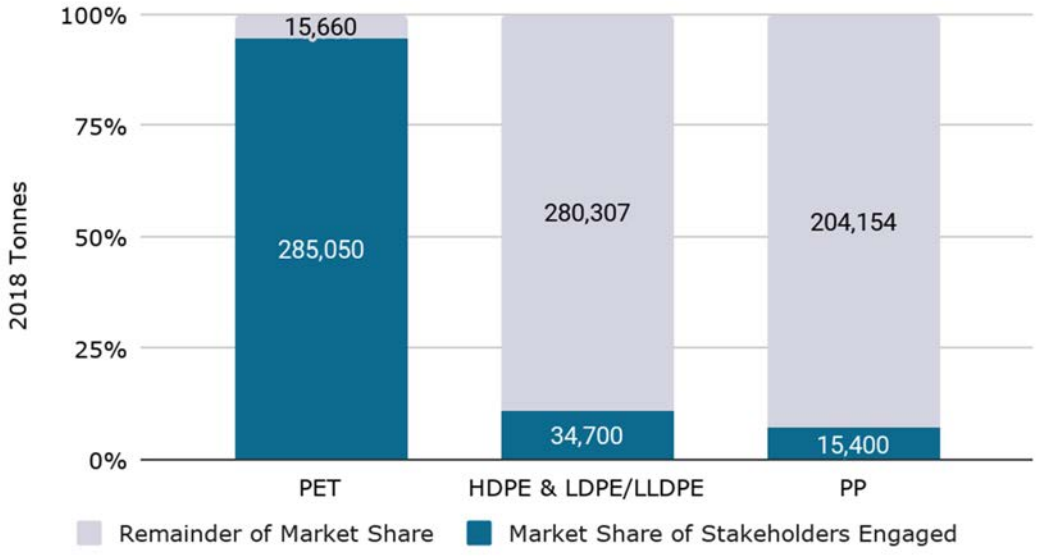


Figure A8.2
MARKET SHARE OF RECYCLERS STUDIED



APPENDIX 9:

THE ENABLING POLICY ENVIRONMENT FOR CIRCULARITY AND INTERVENTIONS

Creating an enabling policy environment for circularity of plastics through a range of policy instruments plays a defining role in the success towards achieving circularity. In this section, the study will analyze the existing national-level regulations, roadmaps and timelines and identify any gaps that are limiting the scale-up of the domestic plastic recycling industry and compare these against a benchmark of best practices from other jurisdictions.

9.1 LIFE CYCLE APPROACH TO PLASTICS CIRCULARITY POLICIES

Assessment of the enabling policy environment for plastics circularity in Thailand can be approached using a life cycle approach for each of the major end-use industries consuming plastics. Over their life-time, plastic products can contribute to various environmental impacts. Taking a life cycle approach considers the range of impacts throughout the life of a product and quantifies this by assessing the emissions, resources consumed and pressures on health and the environment that can be attributed to a product. It takes the entire life cycle into account – from the extraction of natural resources through to material processing, manufacturing, distribution and use; and finally the re-use, recycling, energy recovery and the disposal of remaining waste.[1] Thus a life cycle approach provides a holistic framework for assessment of policies and their impacts.

> For example, taking a life cycle approach can quantitatively address a frequent issue in plastic waste management: whether to recycle or incinerate used plastic products such as plastic bottles. The production of plastic bottles from raw materials requires about 80 MJ/kg (energy per kilogram). Incineration can generate about 3 MJ/kg of electricity and about 10 MJ of process steam from the recovered energy. However, despite this small energy gain, new bottles would have to be produced, requiring high amounts of energy. In contrast, recycling and selective collection consumes 9 MJ/kg while also avoiding the much higher energy consumption used in the production of new plastic from raw materials. Recycling therefore normally results in lower energy consumption than incinerating bottles and producing new ones from raw material.
>
> This example assumes, however, that the plastic is not heavily soiled and is not degraded in the recycling process. If the plastic recycling process produces plastic products of lower value end use applications or under different conditions then it could result in different conclusions.

For each industry, policies impacting plastics circularity can be divided into the following life cycle stages:

1. General Legislative Framework - The overarching legislation which guides policies for the industry.
2. Production - Policies which affect the ways and rules under which plastic products are manufactured.
3. Consumption - Policies which affect consumption behavior.
4. Disposal - Policies which relate to what occurs when a product is sent to a landfill, incinerator, or is leaked into the environment.
5. Recycling - Policies which affect the recovery of plastics after consumption and the actual recycling process.

1 Life Cycle Thinking and Assessment for Waste Management

9.2 PACKAGING: ENABLING POLICY ENVIRONMENT

Across the five industries analyzed in this report, packaging has by far the most developed policies due to its heavy use of plastics and the attention that the leakage of plastics has garnered over the last 5 years. Hence, as described in the table above, the best policies that deal with plastic packaging are those which engage stakeholders across the value chain, plug leakages along the product life cycle and have clear targets which enables each stakeholder to understand what is required of them and hence enables effective implementation.

Table A9.1
PACKAGING: POLICY EXAMPLES ACROSS LIFE CYCLE

Life Cycle Stages	General Policy Framework	Production	Consumption	Disposal	Recycling
Policies	• MSW Legislation • National Targets • Export Import Trade Policy	• Design Standards • Recycled Content Policy • Alternative Materials • Packaging Taxes	• Source Reduction Policies (e.g plastic bag bans) • Green procurement	• Landfill bans • Diversion from landfill targets • Anti-Litter legislation	• Source segregation / deposit refund schemes • Food-grade standards • Extended Producer Responsibility

Table A9.2
PACKAGING: CURRENT POLICIES ACROSS LIFE CYCLE

= *Best Case Practices*

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions			
		Singapore	India	European Union	Japan
General Legislative Framework	Plastic Waste Management Roadmap 2030 outlines plans to eliminate and replace 7 types of single-use plastic with more environmentally- friendly materials by 2022 and recycle 100% of plastic waste by 2027. All plastic waste imports will be banned by 2021.	The Resource Sustainability Act outlines three focus waste streams (including packaging) and strategies to increase collection for recycling rates for these streams.	Plastic Waste Management (PWM Rules), 2016. Collection targets exist and minimum requirements for EPR schemes do not exist in these rules.	The Packaging and Packaging Waste Directive sets targets for the recovery of packaging waste and covers strategies to be implemented by member states to collect packaging waste.	The Basic Act for Establishing a Sound Material-Cycle Society clarifies the responsibilities of all key stakeholders, and articulates fundamental matters for making policies for the formation of a Sound Material-Cycle society.

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions			
		Singapore	India	European Union	Japan
Production	Ban on plastic cap seals* FDA ban on recycled content in food packaging. This ban is however being reconsidered and is expected to be amended by end of 2020. * The plastics cap seal ban is in reality a voluntary agreement with manufacturers not to use the plastic cap seals.	Requires mandatory reporting of packaging use for producers and retailers from 2022 onwards.	Plastics producers need to work out modalities for waste collection systems for collecting back the plastic waste within a period of six months. No targets set. Maharashtra state requires industrial packaging produced to include at least 20% recycled material.	The "essential requirements of packaging" requires the minimization of packaging volume and weight, design of packaging for reuse or recovery and the encouragement of recycled materials usage in packaging. The EU Commission is also initiating work on new harmonized rules to ensure that by 2030 all plastics packaging placed on the EU market can be reused or recycled in a cost-effective manner.	Requires payment of a recycling fee by manufacturers to the designated organization for recycling.
Consumption	Bans use of single-use plastic bag* The 2nd Green Public Procurement Plan encourages green consumption within the government.	No legislation for consumer behavior yet.	Waste generators including institutional generators, are required to segregate plastic waste.	The Single Use Plastics directive bans selected single-use products made of plastic for which alternatives exist by 2021 and implements EPR systems for others.	The Japanese government has plans to make plastic shopping bag charges mandatory.
Disposal	There are no targets for diversion from landfill or landfill bans currently in Thailand.	The Zero Waste Masterplan aims to reduce waste sent to landfill by 30% by 2030.	Local bodies are responsible for segregation, collection, storage and disposal. No targets set. Local bodies are required to encourage use of plastic waste for road construction or energy recovery or waste to oil or co-processing in cement kilns under Plastic Waste Management Rules 2016.	The EU Landfill Directive aims to phase out landfilling for recyclable material by 2025.	There are no targets for diversion from landfill or landfill bans currently in Japan.

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions			
		Singapore	India	European Union	Japan
Recycling	There are no EPR, take-back, or source segregation regulations currently in Thailand.	A deposit refund system has been announced to be implemented in 2022 and is currently undergoing industry consultations.	The draft 2019 National Resource Efficiency Policy sets targets for packaging recycling including 100% recycling rate for PET by 2025 and 75% recycling and reuse rate for other plastics by 2030.	The Single-Use Plastics Directive establishes EPR systems, by 2025, which covers the costs of collection, transport, treatment, cleanup of litter and awareness-raising measures for all packaging. The directive mandates: (a)new recycling target for plastic packaging, set at 55% in 2030; (b)Specifically for plastic PET bottles a 25% recycled content target by 2025 and 30% recycled content target by 2030; (c)Collection target of 77% of single-use plastic drink bottles by 2025 and 90% by 2029 through EPR or through deposit refund schemes	Act on the Promotion of Effective Utilization of Resources fosters the recycling of reusable resources.

There are three key lessons to be gained from the above assessment on circularity for the packaging industry:

1. The EU has the best policies for packaging circularity except for the general legislative framework where Japan has the advantage. This reflects the EU's expertise and experience in the Circular Economy. For example, the "essential requirements of packaging" by the EU establishes rules on packaging design to minimize its impact on the environment and to improve recyclability of packaging. By 2025 at least 55% of all plastics packaging in the EU are required to be recycled. As of 2017, this rate is at 42%. The clear requirements and targets mean that there is less confusion and better enforcement. This also reflects the strong governance that the EU and its member states have that enables them to enforce these rules across all the stakeholders in the EU. Therefore, should the Thailand government want to set its ambitions high, it should look to the targets of the EU as a reference point.
2. Japan has a better general legislative framework than the EU as the Basic Act for Establishing a Sound Material-Cycle Society is an enforceable law with details on how stakeholders should act to increase collection of recyclables. On the other hand, while the Packaging and Packaging Waste Directive of the EU is mandatory (i.e. the targets and actions listed within it must be complied by member states), the directive must be interpreted by member states and then laws in each member state must be enacted to comply with the directive. It is not, by itself, a legislation hence is not applicable to the Thai context. Hence, Japan's Basic Act for Establishing a Sound Material-Cycle Society can be used as a solid reference point to draft an overarching Circular Economy legislation for Thailand.
3. Thailand can draw on the example of Singapore's mandatory reporting requirement of packaging use for producers and retailers to plan for the initial stages of implementing an EPR system. This mandatory

reporting by Singapore, which will begin from 2022 onwards, is a fact-based mechanism to arrive at relevant Extended Producer Responsibility measures and to track progress on plastics packaging circularity targets.

4. While Thailand has some policies which are positive in terms of encouraging circularity (e.g. bans on plastic cap seals and single use plastic bags), interviews with stakeholders as part of this study reveal that these "bans" are, instead, voluntary agreements made by manufacturers and retailers to not produce plastic cap seals and single use plastic bags. Therefore, this might leave some stakeholders not complying with the "ban" as it has no legal standing and is thus not enforceable. This leaves the door open for a future roll back of the "ban". Furthermore, policies such as the ban on the use of recycled content for food packaging is counter-productive as it eliminates local demand for recycled materials resulting in any food grade recycled products to be exported. This eliminates local demand for high value products, while also making the prices of food grade recycled materials vulnerable to global fluctuations.

9.3 ELECTRONICS: ENABLING POLICY ENVIRONMENT

Table A9.3
ELECTRONICS: POLICY EXAMPLES ACROSS LIFE CYCLE

Life Cycle Stages	General Policy Framework	Production	Consumption	Disposal	Recycling
Policies	• MSW Legislation • National Targets • Export Import Trade Policy	• Design Standards	• Source Reduction Policies • Right to Repair • Green procurement	• Landfill bans • Diversion from landfill targets	• Source segregation • Take-back obligations • Extended Producer Responsibility

As plastics are built into electronics, this section will discuss policies related to the recovery of electronic waste and the plastics within it interchangeably. For electronics, a key policy is to ensure that the electronics are easily disassembled so that its component parts can be separated to be fed into their specific recycling processes. While e-waste has a generally high value in the informal recycling market, its high value is derived from its electrical components (e.g. copper wiring, circuit boards). Plastic components of e-waste are not as well recovered as the electrical components as they are either too low value compared to the electronic components or are designed such that it is too difficult to separate from other components to be worth recycling. Hence, formal collection systems with clear recovery targets for all materials need to be implemented to ensure that all parts of an electronic waste are recovered.

Table A9.4
ELECTRONICS: CURRENT POLICIES ACROSS LIFE CYCLE

= *Best Case Practices*

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
General Legislative Framework	Even though there was a National Integrated E-waste Management Strategy Phase II: 2012-2016, there is no active e-waste legislation. The Act on the Management of WEEE and Other End-of-life Products has been in a draft stage since 2015.	The Resource Sustainability Act deals with e-waste as one of its three priority waste streams	A "Circular Electronics Initiative" will be released which will act as the regulatory framework for electronic waste	The Home Appliance Recycling Law divides the responsibilities of stakeholders (e.g. manufacturers, consumers) for the recycling of electronic waste

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
Production	No legislation currently exists which affects production of electronics	No legislation currently exists which affects production of electronics.	The Ecodesign Directive, as part of the Circular Electronics Initiative, will ensure devices are built for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling	Under the Home Appliance Recycling Law, manufacturers are required to take back home appliances, which they have manufactured or imported from retailers and recycle them.
Consumption	No legislation currently exists which affects consumption behaviors.	No legislation currently exists which affects consumption behaviors.	The Right to Repair is included as part of the Ecodesign initiative.	Consumers are obliged to dispose of electronics appropriately and pay for the costs for collection and recycling.
Disposal	No legislation currently exists which affects disposal of e-waste.	No legislation currently exists which affects disposal of e-waste to the incinerator.	No legislation currently exists which affects disposal of e-waste to the landfill or incinerator.	No legislation currently exists which affects disposal of e-waste to the landfill or incinerator.
Recycling	No legislation currently exists which affects collection of e-waste.	The Resource Sustainability Act will in the future establish a Producer Responsibility Scheme (PRS) where producers of electronic products must finance the PRS for e-waste collection.	The WEEE Directive 2012/19/EU Directive provided for the creation of collection schemes where consumers return their WEEE free of charge.	Retailers are to provide take back services for appliances from households and business and deliver them to manufacturers.

There are two key lessons to be gained from the above assessment on circularity for the electronics industry:

1. Japan is the clear best case practice for an enabling policy environment for circularity in electronics across all stages of the life cycle. The Home Appliance Recycling Law is a comprehensive legislation which assigns responsibilities for each stakeholder across the product life cycle. In essence, it compels stakeholders such as retailers and manufacturers to provide for collection infrastructure such as drop-off sites and take-back services. For stakeholders who do not have the ability to provide collection systems, such as households, recycling fees are mandated to be paid to help fund the collection system. Hence, circular electronic policy formulation in Thailand should draw on this example from Thailand.
2. An active legislation on e-waste is not yet available in Thailand with the last available discussion on the topic discussed in the National Integrated E-waste Management Strategy Phase II: 2012-2016 by the Pollution Control Department. According to the strategy, the Act on the Management of WEEE and Other End-of-life Products is at a drafting stage. For the production, consumption, disposal and recycling stages of the lifecycle Thailand has no legislation.

9.4 AUTOMOTIVE: ENABLING POLICY ENVIRONMENT

Table A9.5
AUTOMOTIVE: POLICY EXAMPLES ACROSS LIFE CYCLE

Life Cycle Stages	General Policy Framework	Production	Consumption	Disposal	Recycling
Policies	• MSW Legislation • National Targets • Export Import Trade Policy	• Design Standards • Alternative Materials	• Source Reduction Policies	• There are no specific policies for automotives	• Source segregation • Take-back obligations • Extended Producer Responsibility

Since automotives are typically scrapped at the end of their life (i.e. not just disposed of as is to the landfill), disposal policies are not relevant in the discussion of circularity of plastics in automotives. Similar to electronics recycling and other plastics in non-packaging applications, the ability to separate the plastic portion from the other materials is key to ensuring that the plastics are able to be recycled.

Table A9.6
AUTOMOTIVE: CURRENT POLICIES ACROSS LIFE CYCLE

= *Best Case Practices*

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
General Legislative Framework	The general regulation regarding automotives in Thailand is the Motor Vehicle Act.	The general regulation regarding automotives in Thailand is the Road Traffic (Motor Vehicles, Quota System) Rules	The End-of Life Vehicles (ELV) Directive 2000/53/EC provides the regulatory framework where ELVs are governed. It establishes design standards, collection systems and responsibilities and recycling targets	The Automobile Recycling Law sets out roles and responsibilities for each key stakeholder in the recycling of ELV.
Production	No legislation currently exists which affects circularity at the production stage of automotives	No legislation currently exists which affects circularity at the production stage of automotives.	As part of the End-Of-Life Directive, automobiles should be designed to facilitate proper dismantling and to allow components and materials to be reused, recycled and/or recovered	The 2000 Law for Promoting the Effective Use of Resources encouraged automakers to incorporate more recyclable materials in the production of an automotive.
Consumption	The commerce industry ban on import of used cars for personal use limits the number of cars sold.	Road Traffic (Motor Vehicles, Quota System) Rules, implements the COE system which limits the amount of automotives purchased in a year	No legislation currently exists which affects consumption behaviors.	Vehicle owners are required to pay a 'Recycling Fee' annually which helps fund collection and recycling of ELV.
Recycling	No legislation currently exists which affects collection of automotives	After deregistration, automotives should either be scrapped or exported.	As part of the End-Of-Life Directive, Extended Producer Responsibility is included where producers have a responsibility to take back automotives.	Manufacturers need to remove Auto-shredding residues, Fluorocarbons, and airbags from ELV before they are sent for recycling

There are three key lessons to be gained from the above assessment on circularity for the automotive industry:

1. Japan has the strongest enabling environment on automobile recycling. Its Automobile Recycling Law clearly tracks the life-cycle of an automobile after its end-of-life and clearly specifies the roles and responsibilities for each stakeholder in the chain. For example, consumers are responsible for the payment of a 'Recycling Fee' which funds collection of End-Of Life Vehicles.
2. The EU's End-of Life Directive has a very good provision which specifies that automobiles should be designed to facilitate proper dismantling. This is important because it then facilitates the separate collection of materials which can then be easily processed according to its specific recycling process.
3. Thailand currently does not have any enabling policy environment for circularity across all stages of the life cycle in the automotive industry.

9.5 CONSTRUCTION: ENABLING POLICY ENVIRONMENT

Table A9.7
CONSTRUCTION: POLICY EXAMPLES ACROSS LIFE CYCLE

Life Cycle Stages	General Policy Framework	Production	Consumption	Disposal	Recycling
Policies	• MSW Legislation • National Targets • Export Import Trade Policy	• Design Standards • Alternative Materials • Green Certification	• There are no specific policies for automotives	• Landfill bans • Diversion from landfill targets	• Source segregation • Dismantling procedure

As plastics used in construction are set in place for the lifespan of the building, consumption policies are not relevant to the discussion on circularity of plastics in construction. Similar to plastics in other industrial uses, policies which encourage the circularity of plastics in construction need to encourage design which allows for easy disassembly of plastic components from buildings. Also, recovery of recyclable materials from demolition waste needs to be encouraged to ensure that plastics are also recovered as it is typically a lower value material than the other materials found in demolition material (e.g. concrete, steel).

Table A9.8
CONSTRUCTION: CURRENT POLICIES ACROSS LIFE CYCLE

= *Best Case Practices*

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
General Legislative Framework	Construction waste is classified as Municipal Solid Waste and hence there are no specific policies with regards to construction waste legislation.	Construction waste is considered non-incinerable waste under the Environmental Public Health (General Waste Collection) Regulations.	The Waste Framework Directive (2008/98/EC) aims to recycle 70% of Construction & Demolition (C&D) waste by 2030. The EU C&D Waste Management Protocol lays out the procedure for managing C&D waste.	The Construction Material Recycling Law sets a target of 95% recycling rate for construction waste. It stipulates procedures for demolition and key stakeholders involved and their responsibilities.
Production	As above	The BCA Green Mark Scheme encourages the use of sustainable materials in construction and the provision of recyclables collection infrastructure.	Sustainable construction is encouraged through private certification schemes.	There are no specific policies with regards to sustainable production in construction.

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
Disposal	As above	Construction waste is considered non-incinerable waste under the Environmental Public Health (General Waste Collection) Regulations and disposed of at the landfill without incineration.	Landfill bans are recommended as part of the EU Construction and Demolition Waste Management Protocol.	There are no specific legislation with regards to disposal of construction waste at landfill.
Recycling	As above	The BCA demolition protocol specifies to carry out sequential demolition where one type of material is carefully dismantled at one time and salvaged for reuse and recycling to maximize the amount of materials recovered.	The EU C&D Waste Management Protocol includes requirements for Waste identification, source separation and collection, Waste logistics, Waste processing, and Quality management.	The Construction Material Recycling Law requires contractors to sort out and recycle wastes generated in demolition work of a building.

There are three key lessons to be gained from the above assessment on circularity for the construction industry:

1. The best enabling policy environments for circularity in construction can be found in multiple countries. However, Japan's Construction Material Recycling Law is the legislation that offers the most comprehensive coverage of actions to be taken after demolition. In particular, the law "requires contractors to sort out and recycle wastes generated in demolition work of a building" and targets 95% recovery of recyclable materials from demolition waste.
2. Aside from that, Singapore's Green Mark Scheme encourages building owners to include more recycled materials to be included in the design of the building as well as providing for recyclables collection infrastructure. Similar recognition schemes are available in the EU, although they are administered through private programs.
3. Thailand's existing regulations cover construction waste under MSW. To ensure the construction industry implements plastics circularity measures, it will be critical to ensure that construction and demolition waste be treated as a separate waste stream with its own general policy framework.

9.6 FILAMENT: ENABLING POLICY ENVIRONMENT

Table A9.9
FILAMENT: POLICY EXAMPLES ACROSS LIFE CYCLE

Life Cycle Stages	General Policy Framework	Production	Consumption	Disposal	Recycling
Policies	• MSW Legislation • National Targets • Export Import Trade Policy	• Design Standards • Alternative Materials	• Source Reduction • Green Procurement	• There are no specific policies for textiles	• Source segregation

Currently, filaments or textiles are not treated as a major waste category. Hence, policies which have a specific focus on textiles are scarce. They are typically treated as part of municipal waste. This study, however, has observed used clothing often has a second life and is being actively traded by the informal sector.

Table A9.10
FILAMENT: CURRENT POLICIES ACROSS LIFE CYCLE

= *Best Case Practices*

Life Cycle Stages	Thailand	Benchmarks from other jurisdictions		
		Singapore	European Union	Japan
General Legislative Framework	There is no specific legislation governing used filaments.	There is no specific legislation governing used filaments.	Policies for textiles collection and recycling is covered under the Circular Economy package.	There is no specific legislation governing used filaments.
Production	There is no specific legislation governing the use of recyclable materials in filament.	There is no specific legislation governing the use of recyclable materials in filament.	The European Clothing Action Plan (ECAP) encourages designers & buyers on more sustainable design practices through the Design for Longevity platform.	There is no specific legislation governing the use of recyclable materials in filament.
Consumption	There is no specific legislation governing the consumption of filaments.	There is no specific legislation governing the consumption of filaments.	The EU GPP Criteria for Textile Products and Services are a voluntary instrument for all EU Member States and public authorities, with the goal of facilitating the inclusion of environmental criteria into public tenders.	There is no specific legislation governing the consumption of filaments.
Recycling	There is no specific legislation governing the recycling of filaments.	There is no specific legislation governing the recycling of filaments.	The 2018 Circular Economy Package requires Member States to ensure that textiles are collected separately by 2025	There is no specific legislation governing the recycling of filaments.

There are two key lessons to be gained from the above assessment on circularity for the construction industry:

1. Filament / textile waste has traditionally been the least prioritized among the various waste streams across all jurisdictions. It was only in 2018, that the EU took significant steps to address circularity for textile waste. The 2018 Circular Economy Package requires Member States to ensure that textiles are collected separately by 2025.
2. The lack of prioritization for textile waste has resulted in Thailand having almost no collection or recycling infrastructure for textiles. This has resulted in ~0% collection for recycling rate for polyester in Thailand.

9.7 SUMMARY: ENABLING POLICY ENVIRONMENT FOR THE FIVE INDUSTRIES

In summary, to create an enabling environment for plastics circularity, a life-cycle approach needs to be taken to ensure that all parts of the value chain are covered. This is because, in many cases, policies across various life cycle stages rely on each other to work. For example, requirements to recycle a certain percentage or use a certain percentage of recycled materials would be ineffective if the materials are not designed to be recyclable in the first place. Hence, to achieve circularity, policies need to address all parts of the circular economy for it to transition from a linear one.

Table A9.11

SUMMARY OF ENABLING POLICY ENVIRONMENT AND BEST CASE PRACTICE POLICY FOR THE 5 INDUSTRIES

= Best Case Practices; ✔ = Policy Exists; Blank cell = Policy does not exist

Life Cycle Stages	Packaging					Electronics				Automotive				Construction				Filament			
	TH	SG	IN	EU	JP	TH	SG	EU	JP	TH	SG	EU	JP	TH	SG	EU	JP	TH	SG	EU	JP
General	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔		✔	✔	✔			✔	
Production		✔	✔	✔	✔			✔	✔			✔	✔		✔	✔				✔	
Consumption	✔		✔	✔	✔			✔	✔	✔	✔		✔							✔	
Disposal		✔	✔	✔											✔	✔					
Recycling		✔	✔	✔	✔		✔	✔	✔		✔	✔	✔		✔	✔	✔			✔	

As shown in the table above, while there are some notable policies in Thailand with regards to plastics circularity, Thailand lags behind best-case examples in jurisdictions such as the EU, Japan and other Asian countries such as Singapore and India in terms of the comprehensivity of policies and the coverage of the plastics life cycle. These gaps need to be addressed to enable it to achieve 100% waste plastics circularity target by 2027 as per the Plastic Waste Management Road Map 2018-2030. Section 5 of this study suggests the interventions needed in the policy environment, prioritization of these interventions and timeline for their implementation.

APPENDIX 10:

FURTHER DEFINITIONS ON CIRCULARITY AND OTHER RELATED CONCEPTS

10.1 FURTHER DEFINITION OF CIRCULARITY

To better understand and utilize this definition for this study on plastics circularity, it's important to dissect the definition. This can be done in three approaches:

1 | Plastics circularity for a strong, innovative and resilient plastics recycling industry

This approach to plastics circularity is the focus of this study and it builds on the foundation of Thailand's existing plastics manufacturing and recycling industries. This approach to plastics circularity includes the following activities:

i. increasing local plastics recycling capacity
ii. increasing production and use of recycled plastics content
iii. moving towards 100% reusable, recyclable, biodegradable or compostable plastics materials

2 | Plastics circularity as a means to address climate change

The world is increasingly becoming aware of the climate crisis. However, the efforts to tackle this crisis have mainly focused on a transition to renewable energy which only addresses 55% of global greenhouse gas emissions. The remaining 45% comes from making the products we use everyday, according to a 2019 report by The Ellen MacArthur Foundation.[2] If countries are serious about achieving the climate goals, they need to address and tackle this remaining 45%. While meeting climate change and related emissions targets is increasingly a large driver for circular economy efforts in the private sector, plastics circularity as a means to address climate change will be built on the foundation of the first approach outlined above.

3 | Plastics circularity as a means to address resource inefficiency

According to a UN Environment report in 2019, each year, 90 billion tonnes of primary materials are extracted and used globally, with only 9% recycled.[3] This is commercially and environmentally unsustainable. In the last two decades, not only have resource inefficiencies and pollution challenges become more severe, countries around the world are seeing the limits of a linear economy which is built in the model of 'take-make-dispose'. The current linear economy system is no longer working for businesses, people or the environment. Addressing the question of resource efficiency through plastics circularity however is out of scope of this study and this approach will not be covered in this study.

10.2 OTHER DEFINITIONS USED IN THE STUDY

In addition to circularity, other terms need to be explained to understand the details and contexts of how the Circular Economy works.

Waste: Waste is defined as "substances or objects which are disposed of, or intend to be disposed of by provisions of National Law" by the Basel Convention.

2 Ellen MacArthur Foundation, "Completing The Picture"
3 United Nations Environment Programme, "Global Resources Outlook"

Municipal Waste / Post Consumer Waste: Municipal waste is waste that has been disposed of by households or commercial entities after consumption. It is collected through the public waste collection infrastructure of the city. Therefore, post-consumer waste is typically dirty as organic waste that is also produced by residential and commercial sources is mixed into the municipal waste collection system.

Industrial Waste / Post Industrial Waste: Industrial waste is waste that is generated from industrial activities. These include materials such as chemical containers, pallet film wraps,and factory offcuts. These wastes are typically disposed of through privately contracted waste collection services. Hence, they are usually less contaminated than post consumer waste as it is not typically mixed with other types of waste unless it has already been contaminated due to the industrial activity it is produced from. In fact, in some cases, factories might engage recyclable collectors to collect their recyclables as it is usually cheaper than simply disposing of the materials.

Recycling: Recycling processes may be categorized as two types; Mechanical Recycling and Chemical Recycling.

- **Mechanical Recycling** is defined as "the processing of plastic waste into secondary raw material or products without significantly changing the chemical structure of the material" by the Basel Convention. For example, the flaking and pelletization of post-consumer PET bottles into rPET pellets is an example of mechanical recycling.
- **Chemical Recycling:** the Basel Convention defines Chemical Recycling as "the depolymerization of long polymer chains into monomers through a chemical reaction by means of heat and/or chemical agents to produce monomers, chemical raw materials and/or fuels". For example, the pyrolysis of multilayer flexibles into refuse derived fuel is an example of chemical recycling.

With regards to circularity, mechanical recycling is usually preferred as it requires less energy and has a lower technological requirement. Furthermore, it is possible to obtain the original product back from through mechanically recycling waste recyclables hence achieving true circularity. On the other hand, chemical recycling is able to handle most types of material that are not yet recyclable through mechanical recycling methods (e.g. multi-layer flexibles).

Specifically for mechanical recycling, circular recycling, where the product of the the recycling process is similar to input material (e.g. bottle-to-bottle recycling), is preferred to downcycling, where the products are different than the original input (e.g. PET to rPET fibre). This is because downcycling degrades the integrity and quality of the material and hence, reduces the value. This means that the incentive to collect these materials will then be lower compared to a truly circular recycling process.

Note: The report mentions the term smaller recyclers and larger recyclers. In the context of this report, larger recyclers are defined as recyclers with a capacity of more than 3000 tonnes per year. While other recyclers will be defined as smaller recyclers.

Energy Recovery: Energy recovery is defined as the generation of heat, steam or electricity through the process of utilizing waste (plastics) as substitutes of primary fossil fuel resources for the production of fuel, for energy recovery. This is the least preferred method for recycling as it is the least efficient. However, for governments it is a convenient method to tackle two issues, waste management and electricity generation, with one solution.

APPENDIX 11:

EXISTING INDUSTRY-LED EFFORTS

This section reviews three of the leading existing industry-led efforts within Thailand to collect and recycle plastics.

Thailand Public Private Partnership for Plastic and Waste Management (Thailand PPP Plastic)

The Thailand PPP Plastic platform comprises 33 organizations from the government sector, private sector and non-profit organizations. It was established in June 2018 and was formally appointed to be the 3rd Working Group Group of Plastic Waste Management Sub-Committee in August 2018. Its main objective is to reduce marine plastic debris by at least 50% by 2027 through its mission to "connect the dots and be a center of networks to build a plastic circular economy focusing on infrastructure improvement, innovation, and education". The other objective is to create a circular economy for 100% of all waste plastics in Thailand by 2027.

It aims to achieve this by working with the government at national and local levels to shape the appropriate policies that support a circular economy and by working with all other stakeholders to improve current systems and infrastructure. Thailand PPP Plastic has 5 focus areas:

1. Infrastructure
2. Education
3. Innovation
4. Policy & Legislation
5. Database

Under the infrastructure and education focus areas, the platform is administering two pilot projects in Rayong and Klongtoey to test circular economy business models with the aim of achieving 100% of plastic waste within 5 years before expanding the pilot. Currently the pilot is collecting and recycling approximately 40 tons of plastics per month.

Under the innovation focus area, it is exploring mechanical recycling of plastics into various applications such as plastic roads, bins, bricks, shirts and artificial wood and chemical recycling of plastics with Sepco Industries, a pioneering Thai company that operates a plastics to oil plant in Saraburi province.

Under the database focus area, Thailand PPP Plastic has collaborated with the Pollution Control Department to produce a material flow analysis of eight targeted plastic products in Thailand.

At the stakeholder meeting with Thailand PPP Plastic, the coordinator for the platform highlighted that the participants are currently creating a detailed action plan in response to Thailand's national Plastic Waste Management Roadmap 2030.

Based on stakeholder interviews with member companies, several companies highlighted that the initiative is very useful for their business and offers a collaborative platform consisting of all the parties along the value chain (producers, convertors, recyclers, government, NGOs, academics) and that without these collaborations a national unified mission to reduce plastic marine debris 50% by 2027 cannot be fulfilled.

However not all companies necessarily believe that Thailand PPP Plastic offers the ideal platform. Some have highlighted that the initiative is moving too slowly and has not produced significant results, while other potential members from the private sector have highlighted they would only join the initiative if their messages, comments, obstacles could be heard by the government that could then lead to solutions or improvements towards implementing circularity. Others have yet highlighted other industry platforms such as the Alliance to End Plastic Waste could be a better alternative.

Packaging Recovery Organization (PRO)

A Packaging Recovery Organization (PRO) is a non-profit entity which is formed under the auspices of a mandatory or voluntary Extended Producer Responsibility (EPR) system by consumer goods and packaging companies to coordinate strategies of collecting post-consumer packaging for recycling.

At the start of 2020, a group of consumer goods and packaging companies in Thailand have initiated a feasibility study of setting up a voluntary, industry-led PRO in Thailand. As the study is still ongoing there are no publicly announced targets and roadmaps the PRO.

Consumer Products Roundtable on Plastics (CPRP)

The Consumer Products Roundtable on Plastics (CPRP) is an informal discussion platform formed in 2019 by a group of consumer goods corporations to discuss key initiatives for the business community to work together to manage plastic waste. The objectives of the CPRP are to:

1. Establish a concerted commitment from leading businesses and relevant stakeholders to address plastic waste crisis and collaborate to set up a model province in Thailand for waste management system and move towards zero plastic waste, and
2. To study from the model province case study and analyze and take the lessons learned to improve the project implementation, potential partner identification and project rollout plan

The CPRP is aimed at focusing on four materials - PET, HDPE, PP, and multilayer flexibles. Some of their key actions that they will take are government advocacy, behavior change creating a pilot model province for plastic waste management. The specific activities and impact of CPRP are not publicly available and were not provided by the stakeholders interviewed.

APPENDIX 12:

PLASTICS VALUE CHAIN STAKEHOLDER CATEGORIES

Achieving circularity requires engagement of stakeholders across the entire plastics value chain. Six of the key private sector stakeholders that is discussed in this study are:

1. Resin Producers - Resin producers produce virgin resin (e.g. PET, PP, PE) from crude oil that is needed as feedstock for production of plastic goods.
2. Converters - Converters use the resin produced by resin producers, and in some cases recycled resins produced by recyclers, to manufacture plastic products.
3. Retailers - Retailers sell the plastic products manufactured to consumers.
4. Collectors - Collectors are informal workers who collect the plastic products after consumption to re-sell for recycling.
5. Aggregators - Aggregators collect large quantities of post-consumer or post-industrial plastics from their supply chain (consisting of collectors and junk shops) to re-sell to recyclers.
6. Processors & Recyclers - Processors and Recyclers convert the waste plastics collected by the collectors and aggregators and convert them into the recycled raw materials

APPENDIX 13:

RESIN TO RECYCLING ECONOMIC CLUSTER IN THAILAND

Thailand classifies its waste management and recycling industries into 3 broad categories of factory licenses that businesses need to acquire for their operations:

- Factory type 101 (Central waste treatment plant)
- Factory type 105 (Sorting and/or landfill facility of waste)
- Factory type 106 (Recycling facility in which unusable industrial product wastes are utilized in production process to produce raw material or new product)

As of May 2020, Thailand has 733 factories registered with the Ministry of Industry under the factory code 106, which covers all types of waste recycling. A specific breakdown of only plastic recyclers is unavailable, however based on industry interviews and field visits to recyclers during the course of this study, the majority of the plastic recyclers are located in the provinces surrounding Bangkok. This is validated by data from the Ministry of Industry, which shows that the top nine provinces where almost 80% of all the recycling factories in Thailand are located are within a maximum radius of 130km from Bangkok. Thus, the main recycling economic cluster in Thailand is located in the central region.

Figure A13.1
TOP PROVINCES WITH THE MOST RECYCLING FACTORIES IN THAILAND

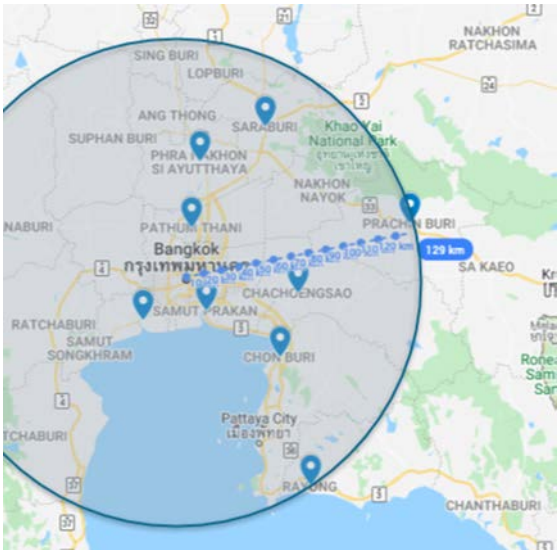
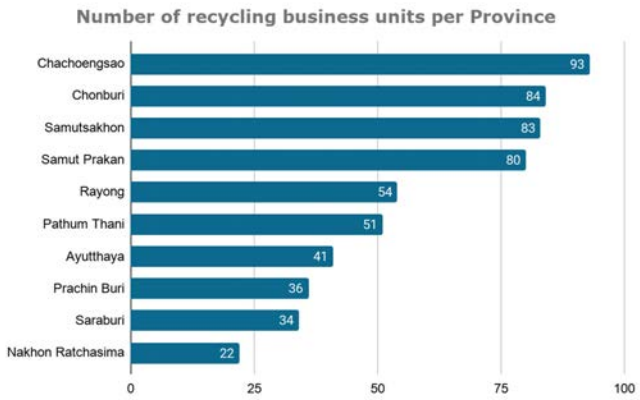


Figure A13.2
BREAKDOWN OF TOP NINE PROVINCES WITH MOST RECYCLING FACTORIES (FACTORY CODE 106) IN THAILAND



APPENDIX 14:

BIOPLASTIC ALTERNATIVES

Note on private sector stakeholders on bioplastics; PTTGC also owns 50% of Natureworks LLC, the world's largest PLA producer based in the US (Natureworks does not have installed capacity in Thailand). Additionally, Thai PET Resin Company (TPRC, also a subsidiary of PTTGC) also has the ability to produce partially bio-based PET using bio-based monoethylene glycol feedstock however the installed capacity is not listed and is expected to be relatively small. Global Green Chemicals (GGC, also a subsidiary of PTTGC) is another important stakeholder in the bioplastics value chain in Thailand. GGC has three product lines which includes raw materials needed as feedstock for bioplastics production.

In general, there are two main criterias that need to be fulfilled for bioplastics to be a viable and sustainable alternative to plastics derived from fossil resources:

1. Supporting policies and standards. This includes:
    a. Policies which prohibit the use of plastics from fossil resources;
    b. Policies that encourage the widespread adoption of bioplastics in single use applications;
    c. Standards that govern the manufacturing and distribution of bioplastics and which also prevent non-bio-degradable such as oxo-degradable plastics from flooding the market
2. Post-consumer stage infrastructure. This includes separation, collection and recycling infrastructure in the post-consumer stage of bioplastics.

In Thailand, only the first criteria of supporting policies and standards have received some attention from government agencies however the criteria has not been optimally addressed thus far. For example, bioplastics bag demand in Thailand has received a boost since the 1st Jan 2020 voluntary ban on plastic bags usage in major stores. However the "voluntary ban" only covers major retailers and does not have legal standing to mandate change. Additionally smaller retailers and shops which form a majority of the marketplace are not covered under this "voluntary ban".

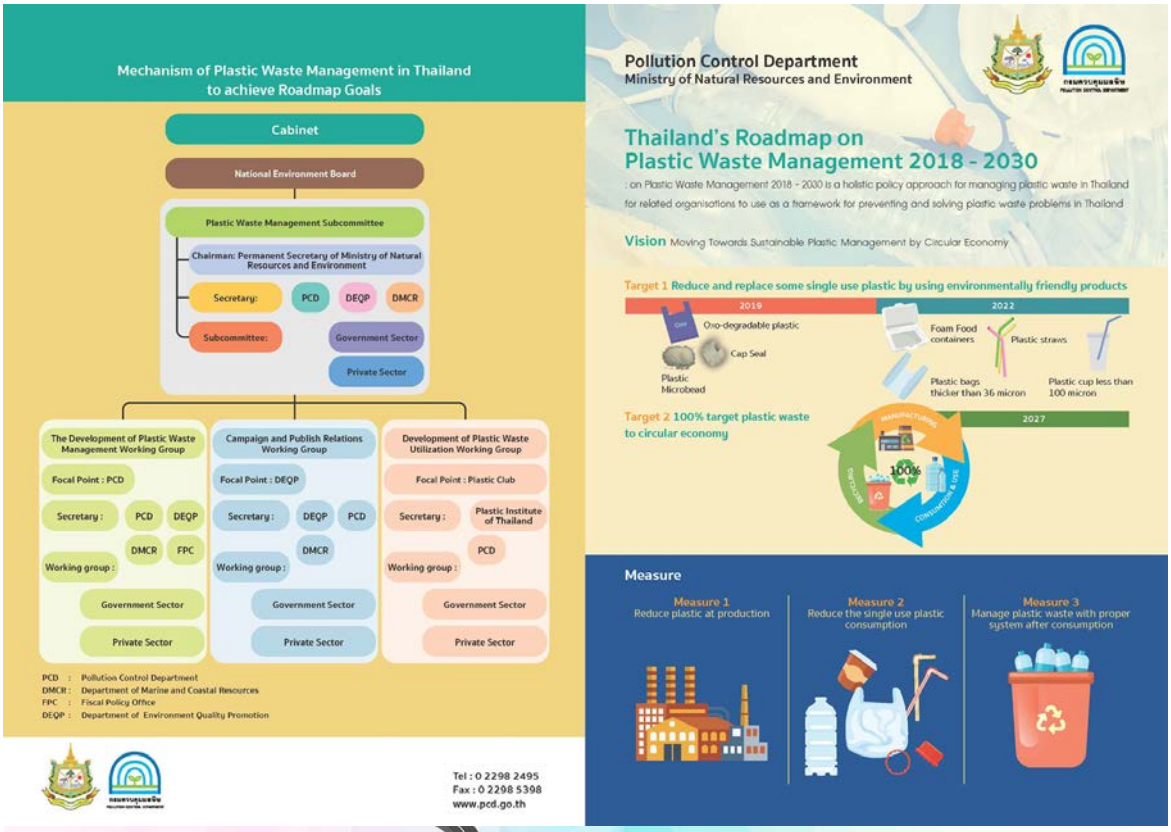
Addressing concerns of diversion of food resources to bioplastics production, bioplastics industry representatives interviewed for this study highlighted that approximately 100,000 TPY of sugar is used as raw material to produce feedstock for bioplastics production. In comparison, Thailand as the world's second largest sugar producer produces 10 million TPY of sugar. Thus the bioplastics feedstock represents 1% of the total sugar consumption in Thailand. Additionally, bioplastics produces at least 10 times more value for the end product compared to processed sugar. For e.g. processed sugar is sold at $0.10 / kg however bioplastics are sold on average at $1 / kg.

While bioplastics currently remain a very small portion of the plastic resins consumed in Thailand, given that government's focus on addressing marine plastics and the Thailand 4.0 policy which has identified biofuels and biochemicals as growth engines, bioplastics share of the total resins consumed in Thailand is expected to grow.[4]

4 Thailand's Petrochemical Industry

APPENDIX 15:

ROADMAP ON PLASTIC WASTE MANAGEMENT 2018 -2030



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